SPACE EXPLORATION AND HUMAN WELFARE

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Deputy Administrator, National Aeronautics
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(First AAS Guest Lecture in the Astronautical Sciences,
American Astronautical Society, December 27, 1958,
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For centuries man envied the birds of the air in their freedom of motion. Some wrote imaginative tales of the time when man would fly through the air and sought to forecast and describe that future environment. They tried to foresee the impact on human life and thinking. Other men sought to translate the dreams and visions of human flight into accomplishment by applying the limited technical knowledge of their day to the construction of practical devices. Finally on December 17, 1903 the conquest of the air began. The event passed almost unnoticed at the time.

For centuries also some men have speculated about the exploration of interplanetary space. As a boy, I, like many of you, read and was enthralled by the novels of Jules Verne. At that time the journey from my grandfather's farm to the nearest town twelve miles away and return took the better part of a day by horse and wagon. Fantastic as Jules Verne's story of travel to the moon appeared when it was written, the story now seems a tribute to his marvellous vision of the future.

On October 4th of last year the first step into outer space was taken when Russian scientists launched the first man-made moon into an orbit around the earth. Within a year man himself will venture briefly into nearby space in the X-15 airplane and in several years will orbit the earth and return safely. The exploration of space by unmanned vehicles carrying scientific apparatus has already begun; exploration by man will follow.

Comparison of the exploration of space with the exploration of the atmosphere reveals many similarities and many differences. In one sense both are merely milestones in man's technological progress. However, in attempting to assess the relation of space exploration to human welfare, it is instructive to imagine one's self on the scene at Kitty Hawk when the fragile cloth, wood, and wire vehicle flew through the air for less than a minute. Look at the Wright airplane on your next visit to the Smithsonian Institution. One wonders how one would have assessed the future impact of the airplane on human life. Who could have foreseen the amazing increases in speed, altitude, size, range, and safety and the manifold uses of airplanes in peace and war? What would have been our attitude toward enlisting public opinion and financial aid from the government for the support of the development of the airplane?

Today we as citizens have similar problems of assessment of why, with what objectives, and how rapidly we shall proceed with the exploration of space. As scientists and engineers some of us are concerned with the way in which we proceed with the task, a question to be discussed later. Let us then look at the objectives of space exploration, because the reasons for proceeding are intimately related to judgments of the value of the objectives to be attained. These objectives are aimed toward material and intellectual results.

The probable material benefits of space exploration are both direct and indirect. Our first space vehicles are earth satellites and space probes. The first practical applications appear to be those of satellites to the problems of world-wide communications and of meteorological research and weather forecasting. The last satellite launched by the United States demonstrates in dramatic fashion some of the potentialities of a communications satellite. This accomplishment is but the first step in a development expected to lead to an economically-sound wide-band reliable world-wide communication system. Such a system would permit the transmission of television programs, if the use of the system for such a purpose were considered desirable.

A meteorological satellite would enable world-wide observation of clouds and other aspects of weather as suitable methods and instruments were developed. At present there are available weather observations from a limited number of stations on the land masses of the globe and from a few ships at sea. It seems clear that the much greater amount of information from the world-wide coverage of the satellite would, when suitably processed, increase the accuracy of weather forecasts. Economic studies have shown very large monetary savings from relatively small improvements in accuracy. More accurate forecasts have tremendous economic implications for agriculture, foodprocessing industries, hydro-electric power plants, public utility companies, and numerous other industries.

There are other applications of satellites to more special uses such as navigation and geodetic measurements. Beyond these we enter the realm of speculation and prophesy. We do not know the ultimate role of space vehicles in transportation any more than the few spectators of the early Wright Brothers flight knew of our present jet transports which make the world a neighborhood. Some speculate that the moon and the planets represent a vast new physical frontier, source of new material wealth, but this can not at present be demonstrated. Suffice it to say that there are some clearly seen material benefits to human welfare from space exploration and that there are others, probably more significant, hidden from our view.

In addition to the direct material benefits of space exploration, there are many indirect benefits arising from the fact that space exploration requires the most advanced technology of our time. The limited payloads available in our early satellites required reduction in size and weight of all equipment. Miniaturization of electronic circuiting, which had been developing in various military and commercial equipments, was still further developed. Sophisticated advances in telemetry and communications were accomplished. New developments in materials used in ballistic missile applications will be accelerated by the requirements of space exploration. Thus space technology will contribute to other technical fields as has aeronautical and guided missile technology.

"The Introduction to Outer Space" prepared by the President's Science Advisory Committee devotes considerable attention to the intellectual objectives of space exploration. I quote: "Space technology affords new opportunities for scientific observation and experiment which will add to our knowledge and understanding of the earth, the solar system, and the universe". This objective has been prominent in all of the satellite launchings so far made. The development of satellites has opened up new vistas to scientists engaged in the study of the numerous electrical, optical, and other physical phenomena and of charged and uncharged particles and meteorites in the upper atmosphere and nearby space as well as to astronomers and astrophysicists concerned with the planets, stars, galaxies and the universe. The scientific knowledge of the space environment is needed in the design of vehicles and equipment for all the objectives of space exploration. More complete scientific knowledge of the universe is an ever-present goal of the inquiring mind of man.

I will mention only in passing the defense and national prestige objectives of space exploration which in the context of the world climate of today we believe to contribute by deterrence of actions harmful to human welfare.

Transcending the specific objectives of specific material and intellectual returns from our investment in space exploration is the objective stated by the Congress in the National Aeronautics and Space Act of 1958, that the activities of mankind in space shall be devoted to peaceful purposes and the general welfare. In this setting the exploration of space becomes the most challenging task of our time, one that demands the maximum skills of scientists, engineers, and statesmen and enlists the support of men and women in all walks of life.

We as scientists have a deep interest in all of these objectives but our assignment is that of obtaining the knowledge, advancing the technology of space flight, and proceeding with the exploration of space. We have a broad base on which to build in the technology of aeronautics and guided missiles created within the last decades. That technology and its scientific and engineering foundations have grown in evolutionary fashion, speeds and altitudes of aircraft and missiles increasing to the frontiers of space. As a part of this great advance, propulsion systems, materials, structures, guidance and control, communication, and telemetering developed to such an extent that our first satellites were with some over-simplification largely an assembly of components already in existence. The propulsion systems had been developed to a reasonable reliability through many firings in connection with the guided missile program. The new developments required were not extensive. The large development costs of the rockets and other components were chargeable to the guided missile program.

With these first satellites remarkable progress has been made in scientific measurements of the space environment. The most spectacular and publicized result was the discovery of the Van Allen radiation belt of high intensity associated with charged particles trapped in the magnetic field of the earth. Dr. Van Allen will describe some of his more recent measurements later in the program today and will receive the AAS Space Flight Award at the Honors Night Dinner tonight. Many other important results of an exploratory nature have been obtained on air density, micrometeorites, control of internal temperature of satellites, radio transmission from satellites, satellite trajectories as affected by the shape of the earth, etc.

Notwithstanding these outstanding accomplishments of the first year of space exploration, we can not be satisfied. We must move forward with urgency in a soundly planned orderly program to reach our national objectives. Such a program extends from basic research in the astronautical sciences through applied research and development of components to the accomplishment of space missions. Let us examine some examples of what we need to accomplish.

The radiation field of the earth has so far been examined by devices which give measurements of overall intensity and some limited information about the energy distribution. Most of the measurements are within a distance of less than our earth's radius although the lunar space probes have given some data to much greater distances. None of the measurements approach the interesting regions of the North and South Pole. We need ultimately to extensively sample the radiation field in all directions to as great a distance as we can reach with available space probes and in each case to know as much as possible about the spectral energy composition of the radiation. Since there is every prospect that the radiation varies with time as a result of solar eruptions, we need to repeat measurements at different times. Eventually engineers would like to know enough about the radiation to set up accurately on the ground the radiation environment of space so that its effects on photographic film, transistors, men, etc. could be determined.

Scientists know that no experimental program could be extensive enough to produce all the knowledge desired. Sufficient measurements must be made to guide the formulation of a theory to be checked by further experiments. Thus theory and experiment must proceed hand in hand.

The more comprehensive measurements generally require heavier apparatus and thus greater payload. We are thus led to a consideration of the rocket systems which launch the satellites into orbit or project the probes into space. All of the first stage rockets presently available are heritages from the military guided missile program except Vanguard. Some of the upper stage components have been developed specifically for satellite launching.

Whatever mission one wishes to accomplish in space, the performance as expressed by payload is a direct function of the booster system. Our earliest satellites utilized the Redstone or Vanguard. Increased capacities are available with the intermediate range ballistic missile boosters, Jupiter and Thor. The lunar probes used these rockets as the first stage. Still greater payloads can be obtained with the intercontinental ballistic missile boosters, Atlas and Titan. As recently demonstrated, the 1-1/2 stage Atlas can itself put its final stage and an appreciable payload directly into orbit. With additional staging the payload can be greatly increased.

For still greater payloads required in the more difficult missions a booster of still greater thrust is needed. The National Aeronautics and Space Administration recently announced the selection of a contractor to develop a rocket of 1 to 1-1/2 million pounds thrust. In the interim such thrusts can be obtained by clustering existing rocket engines. When the new rocket engine is available, it too can be clustered to produce several million pounds thrust.

The national booster program includes the development of suitable upper stage rockets, including some using high energy fuels. The Atomic Energy Commission and the National Aeronautics and Space Administration are jointly engaged in projects for the application of nuclear energy to the exploration of space.

Our current guidance systems, although highly satisfactory for ballistic missile use, can only be considered as marginal when viewed in the light of the requirements of space vehicle guidance. Many scientists unacquainted with the problem have been surprised at the effect of relatively small reductions in burn-out speed on the range of probes fired from the earth. If one considers in detail the requirements of launching from a rotating earth, itself moving through space at high speed, toward the moon, also moving through space in a different direction at high speed, it is found that extreme accuracy in firing time, burn-out speed, and direction of travel at burn-out are required to come anywhere near the moon. The problem is far more difficult than that of a hunter standing on a rapidly rotating table shooting at a supersonic airplane. In space missions, it is probable that midcourse and terminal guidance will ultimately be required. Provision of such equipment means additional weight to be placed in orbit, not only in amount equal to the weight of the equipment but also additional weight to provide power and working fluid for attitude stabilization and course correction.

In current satellites the primary power for the scientific instruments and the radio transmitting equipment comes from chemical batteries or from solar energy. Only spin stabilization has been used. As development continues, much greater power will be required for stabilization, attitude control, orbit adjustment, and ultimately for electrical propulsion. Nuclear power appears to be the most satisfactory answer. Much research and development is needed on nuclear reactors of size and weight suitable for internal power for space vehicles and on the turbines, generators, and other devices needed to convert from nuclear to electrical energy.

It was announced on December 17, by Dr. T. Keith Glennan, Administrator of NASA, that the national program includes a manned satellite project, called Project Mercury. Its objective is to begin the manned exploration of nearby space with special reference to the technology needed for the safe performance of such a mission and the reactions of man in the space environment.

Propulsive systems will soon be available of reasonable reliability and of sufficient capacity to launch the required weight into orbit. There are many other problems to be solved. The obvious engineering problems are those of providing a safe environment to protect man from the low temperature and presence of space, from harmful accelerations on take-off and re-entry, from the heating of the vehicle during re-entry, providing deceleration and safe landing. The motion of the capsule must be aerodynamically stable or artificial damper provided. It must be controllable in attitude. Retrorockets must be fitted to return the capsule from orbit. A suitable pilot-escape system must be provided for use in event of a malfunction on launch. These problems are suitable for attack by straightforward engineering methods and for experimental check-out and demonstration.

There are many other factors which require additional research and study, although much work has already been done probably sufficient for Project Mercury. We have already mentioned the discovery of the Van Allen layer of ionizing radiation which is known to include some heavy particles of high energy. If man is to explore space to great distances, we must know much more than we do now about the radiation environment, shielding methods, effects of heavy primary cosmic rays on man, etc. The psychological factors in the space mission environment have received considerable study. Here again no difficulty is expected for the early short time missions with carefully selected personnel, but as space exploration extends to longer durations, this area of research must receive increased attention.

So far I have given some examples of the next steps in the task before us. The exploration of space differs greatly from the exploration of the air. For many years following the flight of the Wright brothers it was possible for an individual to learn and know all there was to be known, to personally build an airplane, sometimes with his own resources, and as pilot to explore the new element. A little later, flight was still an area for a single enthusiast with the support of a patron or of a small group. The exploit of Charles Lindbergh in the New York-Paris flight of the Spirit of St. Louis was a typical example.

Aeronautics changed character rapidly. Science and engineering assumed a predominant role. Knowledge developed far beyond the capabilities of any one individual to digest and use. A social invention was made, that of the design team consisting of many individuals with differing qualifications and specialized knowledge. The leader of the team broke down the development task into specialized problems which could be assigned to different individuals. As progress continued, the specialized individuals became specialized teams. With the coming of guided missiles the complexity of the task brought the necessity for complete system analysis and functional coordination of all the components. Today the group engaged in the development of one of our ballistic missiles comprises thousands of persons in hundreds of organizations.

This remarkable social and technological development reflects two sides of the same coin. As the task grew more difficult, a more complex organization was required. And conversely, as the methods of organization and management developed, the greater the magnitude and complexity of the task that could be undertaken and the greater the possible accomplishment. Accomplishments hitherto unrealizable became practical engineering projects. It is this evolution in our technology and its management which has brought us to the door of space exploration.

At one stage in his plans Christopher Columbus took his project to the Count of Medina Celi. Although interested enough to entertain Columbus for two years, the Count decided that the enterprise was too vast for the resources of one individual and referred Columbus to Queen Isabella. The proposal was then referred to a committee, which reported that the new project was vain and impracticable. I repeat this incident not to indicate that the government still functions in the same manner but that large enterprises require the support of the government.

I do not foresee any projects in space similar to Lindbergh's flight across the ocean. Space exploration is the prerogative of the largest and most powerful nations of the world. Only two have so far begun the task. The task is of such magnitude that we may well enlist the cooperation and skills of all nations in its accomplishment as we proceed to larger and more difficult enterprises.

Many persons have outlined the milestones of space exploration far into the future. About a year ago Jimmie Doolittle listed them as (1) unmanned rocket to the moon; (2) scientific instruments landed on the moon; (3) manned earth satellite and return to the earth; (4) trip around the moon and return; (5) man landed on moon and brought back; (6) establishment of space platform; (7) instruments landed on Mars or Venus; (8) man or men landed on Mars or Venus and brought back; (9) permanent observation station on the moon; (10) interplanetary travel.

These or similar missions lie along the future pathway of space exploration, whether in the order mentioned or some other. Their accomplishment depends on a lot of persistent non-glamourous hard work of a very large number of people on highly technical tasks in many fields of science and engineering. In our off moments we can share the mood of that subscriber to the British magazine, "Spaceflight", identified only by his initials, "J.G.". He wrote "The Subscriber's Lament" in the April 1958 issue, from which I quote two of the three stanzas.

"I joined the British Interplanetary Society to go to the Moon--
Reasonably soon.
I wanted to hear about landings on Venus and Mars
And thrilling Einsteinian flights to the stars.
But, whenever I open the infernal
B.I.S. Journal,
Instead of pictures of exciting, space-suited people
Setting off in some great, gleaming ship as tall as a steeple,
All I find is a welter of maths
Describing their paths.

"Let's hear more about spaceships and stations--
I'm sick of these endless specifications
Of Nikes and Matadors, Snarlers and Mice
(Which just hop about poor Earth's surface, like lice.)
They'll no more carry me to distant planets
Than a sixteenth-century gondola, drawn by gannets.
So come on, you theoreticians, let us reach for the sky
(With a little help from the Ministry of Supply!)
Build me a vehicle, find me a new--
All I ask is a space-ship and a star to steer her to!"

Let's get down to earth for a moment. This welter of mathematics, and the accompanying physics, chemistry, celestial mechanics, geophysics, biophysics, space medicine, psychology, electronics, propulsion, guidance, control, instrumentation, are the necessary foundation on which to build successful missions, whether for scientific measurements of the space environment, for study of the sun and planets and distant galaxies, or for exploration of space by man himself. By experience we learn that there are few short-cuts. Let's get on with the job using the best scientific, engineering, and managerial talent available to us.